Approach

- Test in the lab to isolate and identify sources of errors
- Using basestation simulator as shown in the set-up
- Ultratec TTY on both ends (Tx= Supercom 4400, Rx= Uniphone 1140)
- Testing only the down link, since it represents worst case
- Testing Nokia 6160 with dual mode: Analog and TDMA (IS-136)
- The sensitivity level is specified between -116 dBm and -113 dBm
- RSSI was changed from -50 dBm down to sensitivity levels
- No fading or network effects were added at this point
- FS/LS errors were counted as one error

NOKIA

ANALOG TEST

- RSSI from -50 dBm down to -116 dBm
- Slow data entry (Manual)
- CER can be increased using two methods:
  - (1) Decrease frequency deviation (base station function)
  - (2) Decrease RSSI down to sensitivity levels
- As shown in results, a slight mismatch in peak deviation can adversely affect CER
- CER increases rapidly at and beyond sensitivity levels
- Increased CER is mainly due to expander high attack time
- The high attack time causes the receiver to completely miss the start bit, this effect is more profound near sensitivity levels

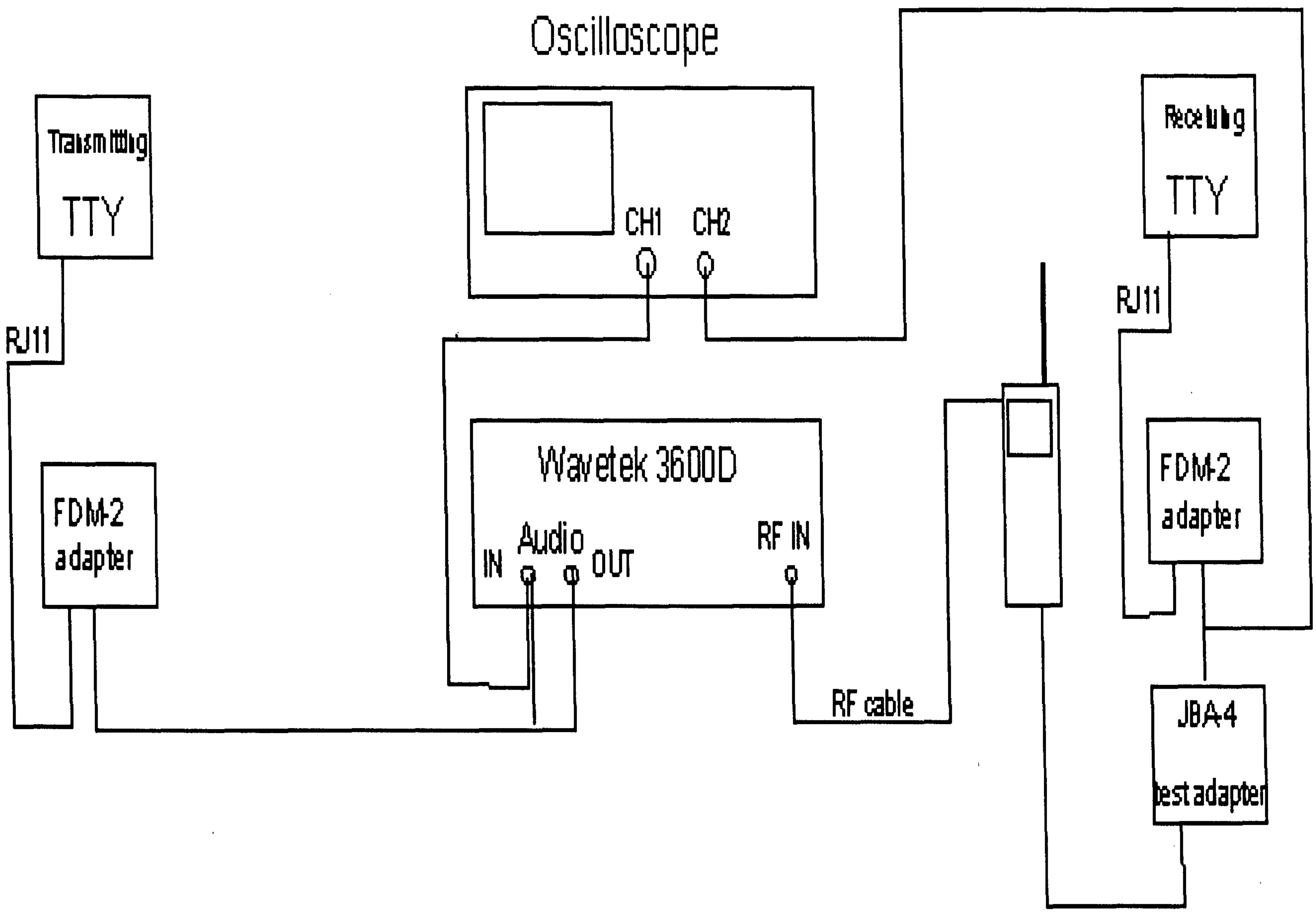
DIGITAL TEST

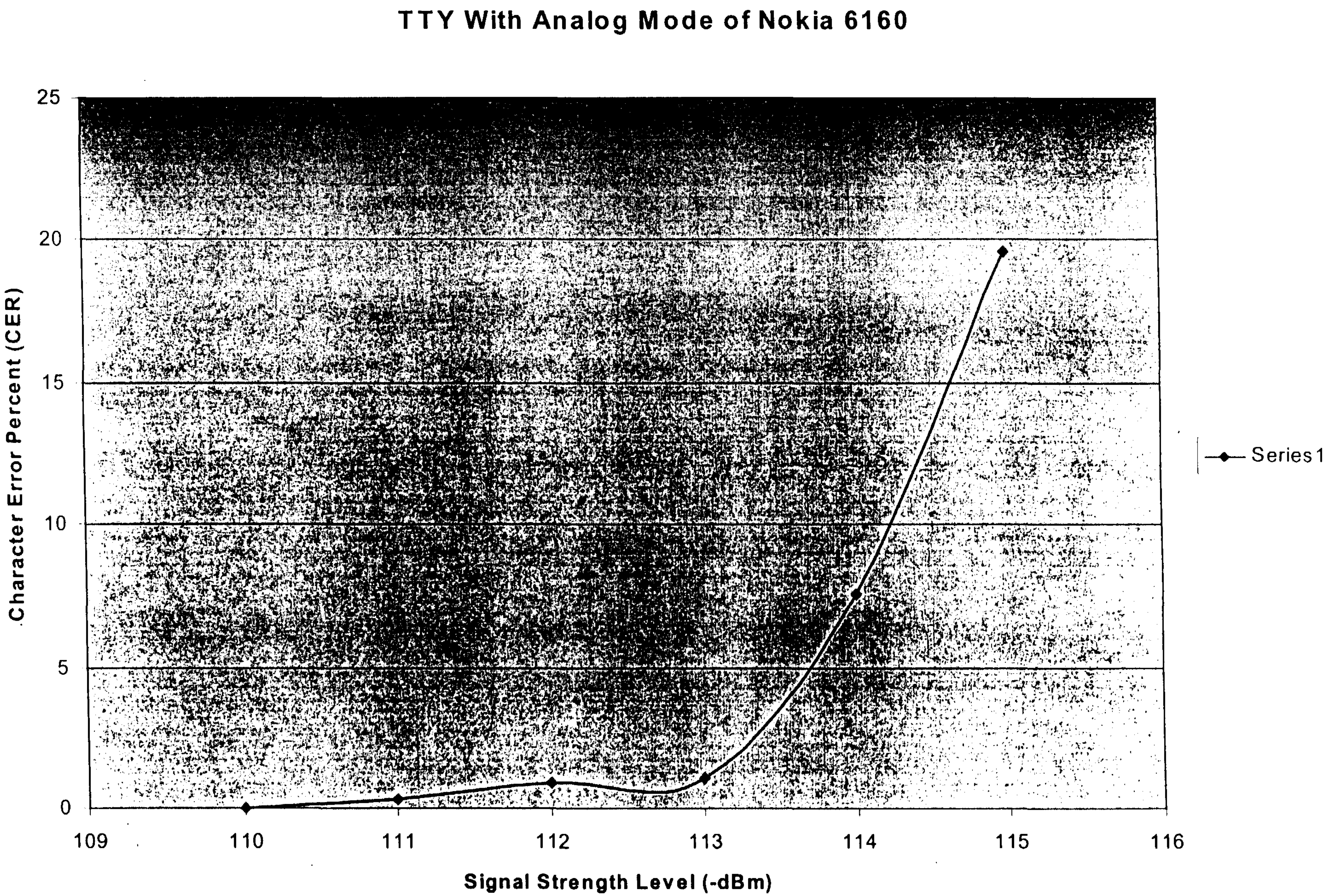
- RSSI from -50 dBm down to -115 dBm
- Slow data entry (manual)
- CER can be increased by decreasing RSSI down to sensitivity levels
- Residual CER is about 2% to 7% at high RSSI levels (It probably reflects the vocoder effects)
- For example, CER = 5% at RSSI = -90 dBm
- CER increases rapidly at and beyond sensitivity levels
- A large percentage of the errors are again due to missing the character start bit (is this due to vocoder attack time?)

WHAT IS NEXT

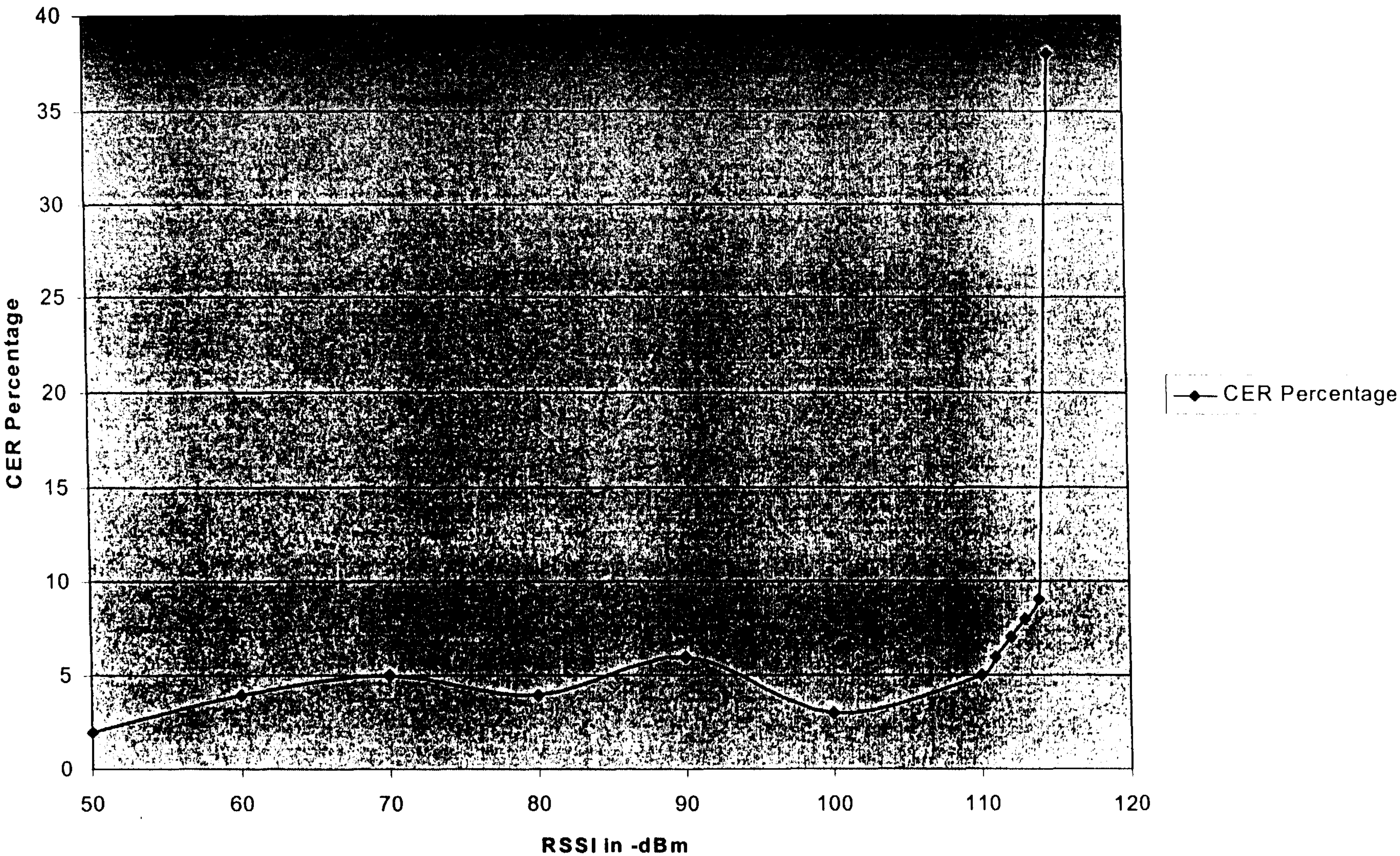
- Repeat these tests while counting FS/LS as N errors?
- Repeat for other technologies
- Repeat while introducing fading (multipath fading simulator)
- Repeat to isolate and test:
  - Hand over effects
  - Vocoder types
  - DTX
  - Frequency Hopping (for GSM)
  - Ciphering (for GSM)
  - Full/half rate effects
- Any others?

TEST SET-UP

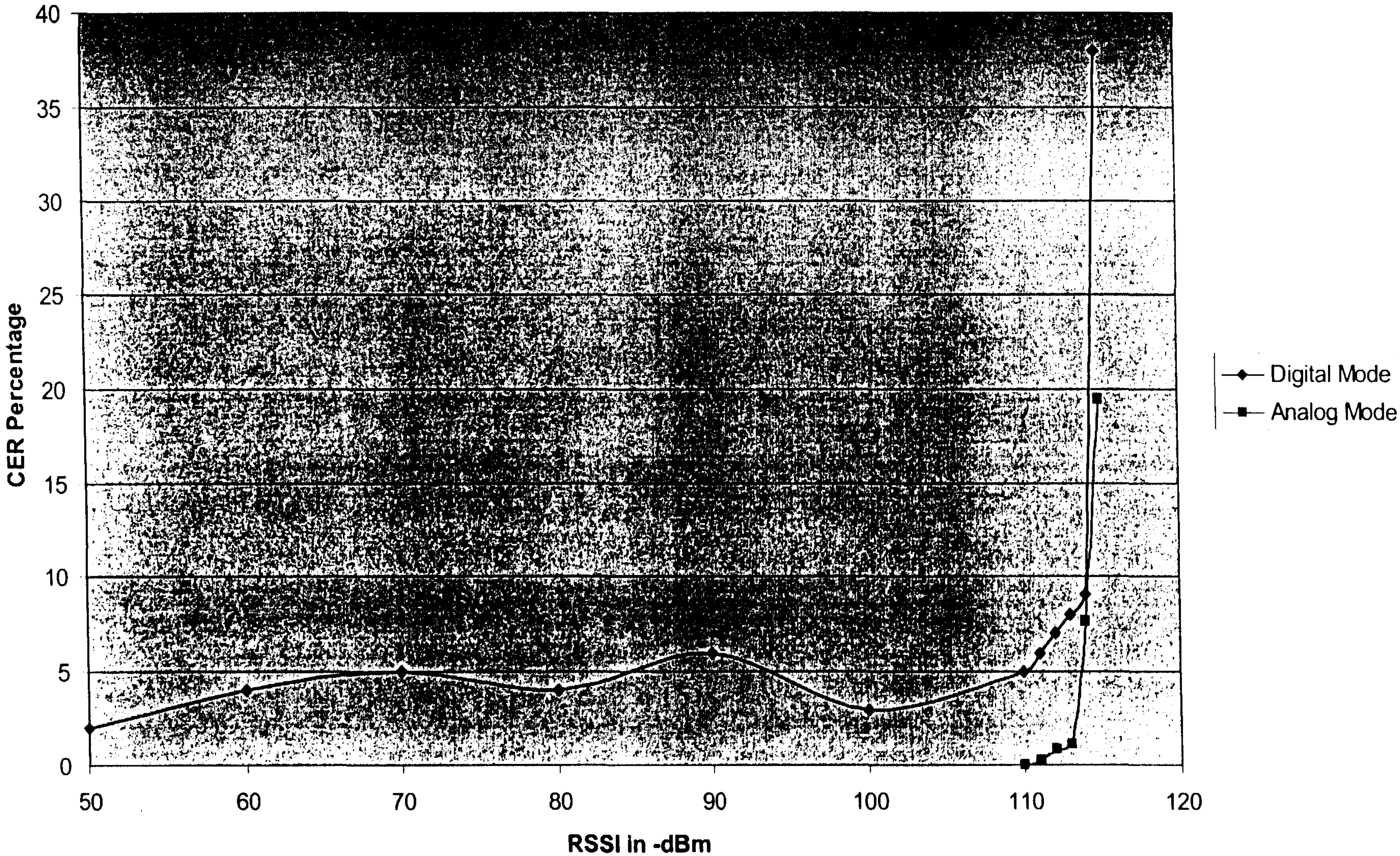

Oscilloscope
CH1
CH2
Transmitting
TTY
RJ11
FDM-2
adapter
Wavetek 3600D
Audio
IN
OUT
RF IN
RF cable
Receiving
TTY
RJ11
FDM-2
adapter
JBA-4
test adapter


TTY With Analog Mode of Nokia 6160
Character Error Percent (CER)
25
20
15
10
5
0
109
110
111
112
113
114
115
116
Signal Strength Level (-dBm)
Series1

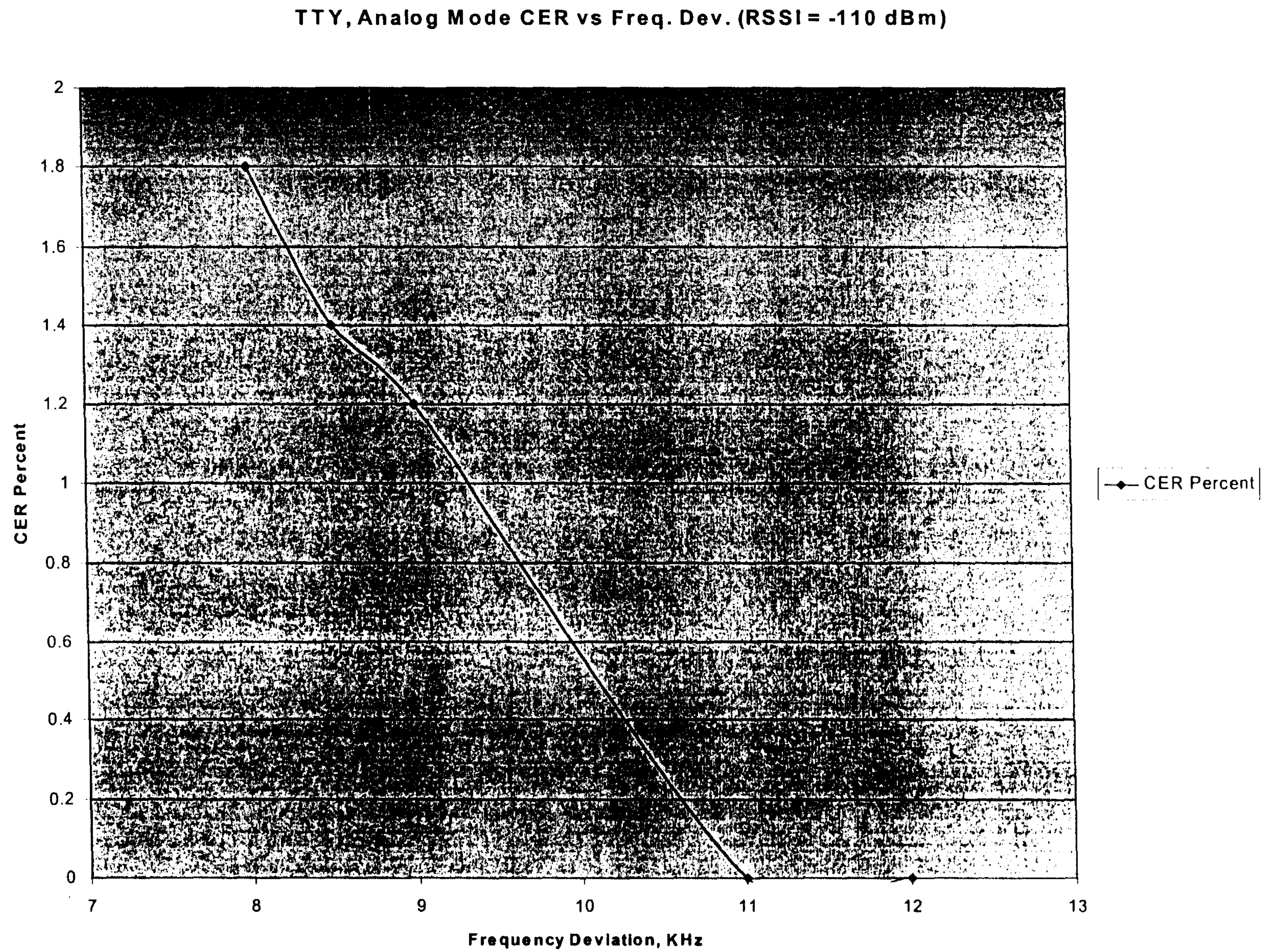
TTY with Digital Mode (Nokia 6160)



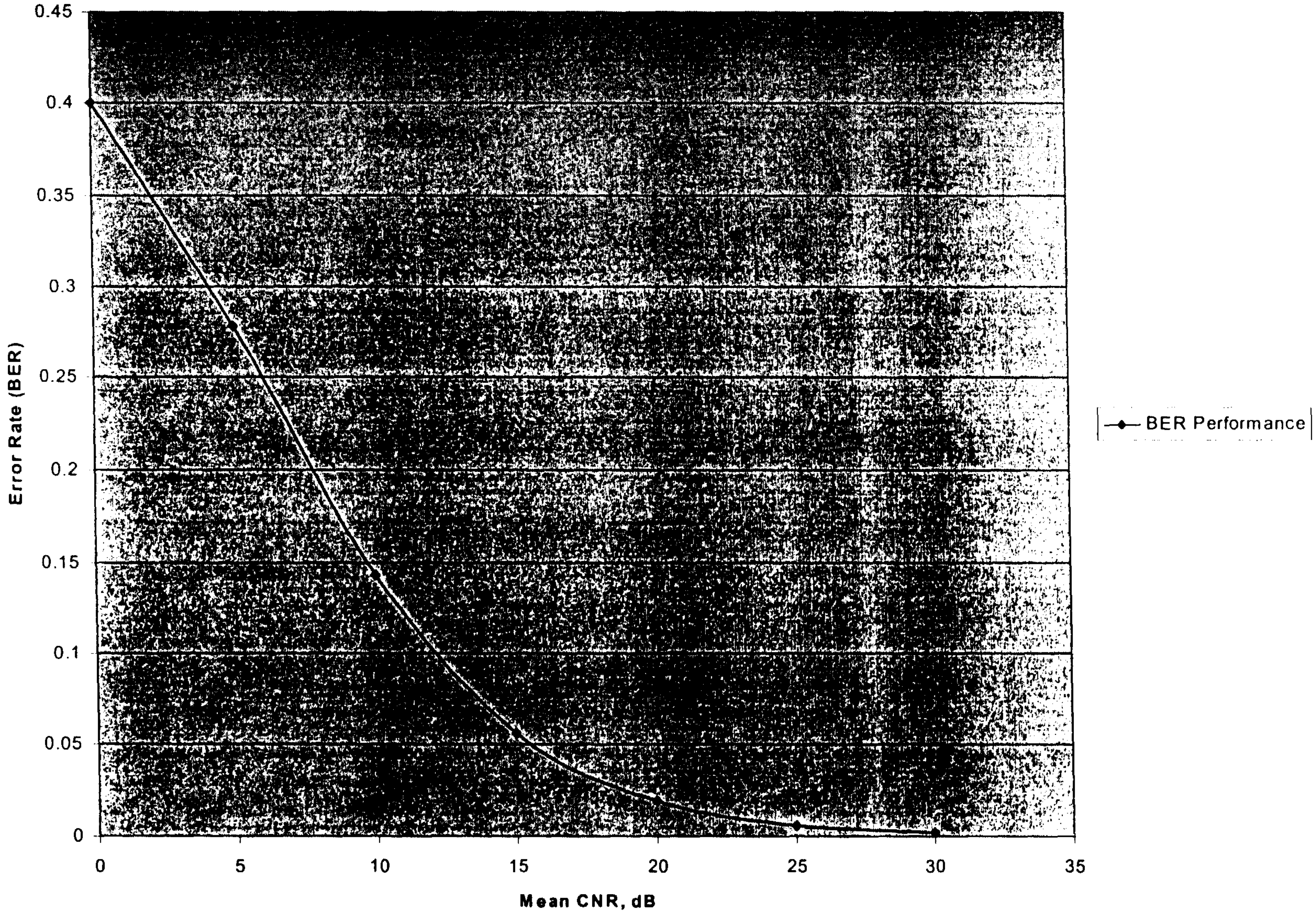
TTY: Analog versus Digital Comparison

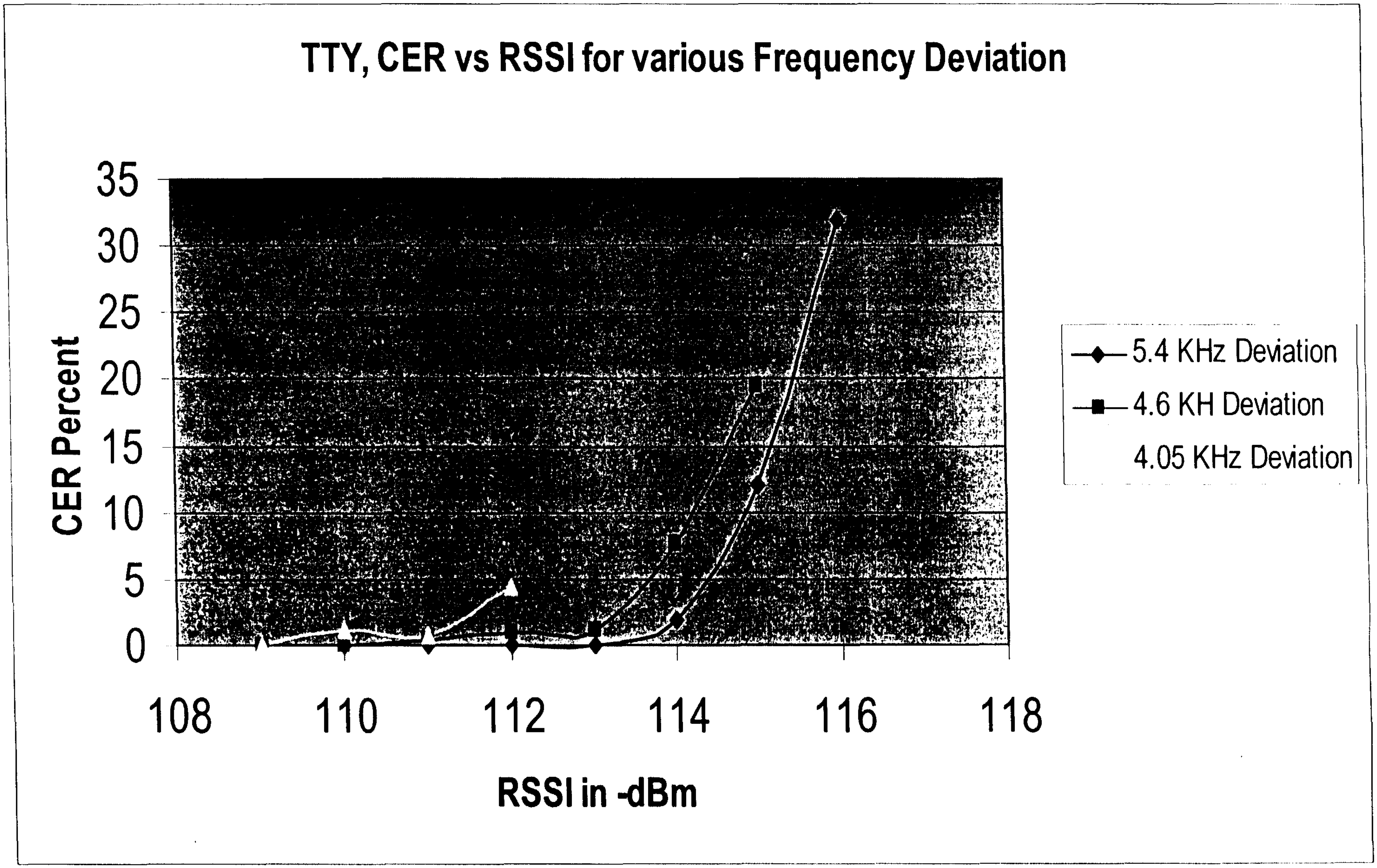


NOKIA


TTY, Analog Mode CER vs Freq. Dev. (RSSI = -110 dBm)
CER Percent
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
7
8
9
10
11
12
13
Frequency Deviation, KHz
CER Percent

Analog Mode, Data BER Performance




TTY, CER vs RSSI for various Frequency Deviation
CER Percent
35
30
25
20
15
10
5
0
108
110
112
114
116
118
RSSI in -dBm
5.4 KHz Deviation
4.6 KH Deviation
4.05 KHz Deviation

APPENDIX I

Philips *Aeon* TTY Interoperability Test Report

Testing with the Lober & Walsh *Mobility* and Ultratec *Intele-Modem* TTY Devices

Jim DeLoach

Version 1.1

2 October 1998

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Issue history

Version	Status	Date	Reason
1.0	Initial Release	7 September 1998	Initial document release.
1.1	Final	2 October 1998	Recalculated results using new score program. Now, results are available that calculate both the true character error rate, and the rate including shift errors.

List of contents

List of abbreviations

ACELP	Algebraic Codebook Excited Linear Predictive (a term used to describe the most current digital voice coder used in IS-136 TDMA cellular systems)
AMPS	Advanced Mobile Phone Standard (an EIA/TIA standard defining an analog cellular air interface)
BACTC	Bay Area Cellular Telephone Company, the A-side cellular provider in the San Francisco Bay Area (also known as "Cellular One")
BER	Bit Error Rate
CDMA	Code Division Multiple Access (refers to a digital cellular air interface technology defined in standard EIA/TIA IS-95)
CTIA	Cellular Telecommunications Industry Association
EIA	Electronics Industry Association
FCC	Federal Communications Commission
FSK	Frequency Shift Keying
IS-136	EIA/TIA Interim Standard-136 (a standards document defining a cellular air interface using TDMA technology)
PCC	Philips Consumer Communications
POT	"Plain old Telephone"
RF	Radio Frequency
RSSI	Received Signal Strength Indication
SP	System Provider
TDMA	Time Division Multiple Access (refers to a digital cellular air interface technology defined in standard EIA/TIA IS-136)
TIA	Telecommunications Industry Association
TTD	Text Telephone Devices
TTY	Teletype

List of references

[1] TTY Test Procedure, Cellular Telecommunications Industry Association, Joint Task Force, Working Group 1/3, 12 February, 1998

[2] Philips *Aeon* TTY Interoperability Test Report -- Testing with the Lober & Walsh *Mobility* TTY Device, Jim DeLoach, Version 0.01, 23 June, 1998

1.

1. Introduction

Philips Consumer Communications (PCC) has conducted a series of live-network tests using the Philips *Aeon* TDMA digital cellular telephone with the Lober & Walsh *Mobility* and Ultratec *Intele-Modem* TTY devices, in our ongoing effort to characterize TTY performance over realistic IS-136 digital cellular channels [2]. Goals of this test were to explore:

- how well different TTY devices interoperate in a cellular environment,
- how TTY performance changes when characters are sent at "full rate" (sent continuously one after another) vs. "half rate" (gaps present between characters, as might be the case with a typical-speed typist),
- how TTY performance differs on digital TDMA channels verses analog, all other factors being equal, in order to baseline performance.

The *Mobility* and *Intele-Modem* were selected because each can be directly connected to a computer to capture the received text, enabling automated results scoring. Automatic scoring is indispensable since manual scoring is (1) excessively time consuming, and (2) prone to errors. Additionally, the designers of these two devices, Lober & Walsh Engineering and Ultratec, have both been very helpful and willing to work with us to overcome problems encountered.

Live calls were made using the Bay Area Cellular Telephone Company (BACTC) Network (a.k.a. "Cellular One") in the San Francisco Bay Area, from an average signal strength fixed location. Our results are shown in the following sections. Test methodology is described in section 2, results in section 3, and conclusions in section 4.

2. Test Methodology

2.1 Test Strategy

This test campaign was designed to explore the following operational scenarios:

- TTY device type and position:
  - *Mobility* (land) / *Mobility* (cellular)
  - *Intele-Modem* (land) / *Mobility* (cellular)
  - *Mobility* (land) / *Intele-Modem* (cellular)
  - *Intele-Modem* (land) / *Intele-Modem* (cellular)
- direction of communication:
  - forward (from the land to the cellular)
  - reverse (from the cellular to the land)
- transmission rate:
  - full rate (simulating a fast typer or an automated system)
  - half rate (simulating a slower typer)
- cellular voice channel type:
  - digital TDMA (IS-136) ACELP vocoder voice channel
  - analog AMPS voice channel

Each possible combination of these four operational scenarios was tested, and thus 32 test permutations performed. Data collects were taken at a moderate signal strength, fixed, location (the author's home in Sunnyvale, California), using the live, Bay Area Cellular Telephone Company (BACTC) IS-136 TDMA network. This location was chosen because it has produced the most reproducible results in the past, and is typical of the well engineered BACTC network. A description of the cellular conditions observed during testing at this location is shown in section 3.1.

2.2 Test Set-up

Audio levels to and from the Aeon cellular phone were matched to each TTY device, with the help of engineers from both TTY manufacturers. However, neither we nor the TTY manufacturers are sure that the levels selected were optimal. Considerable questions remain on the relationship between the signals at the cell phone interface and the signals at the landline, in various networks and in various conditions (i.e. TDMA vs. CDMA vs. analog calls). Indeed, our results (discussed below) suggest that there is an inconsistency between the levels preferred by each manufacturer, and matching that works between two like TTY devices does not work with two differing TTY devices. *PCC recommends that the TTY Forum focus on audio level standardization at the TTY/cellular phone interface.*

The *Intele-Modem* is designed for a landline telephone connection only. Therefor, modifications were required within the unit to bypass the phone interface circuitry and separate the receive and transmit audio. Level conversion was also added. A design for these modifications was provided by Ultratec.

Figures 2.2-1 and 2.2-2 show the test setup in the reverse and forward directions, respectively. In all cases, one TTY device is using the Aeon cellular phone while the other is using a standard landline phone connection.

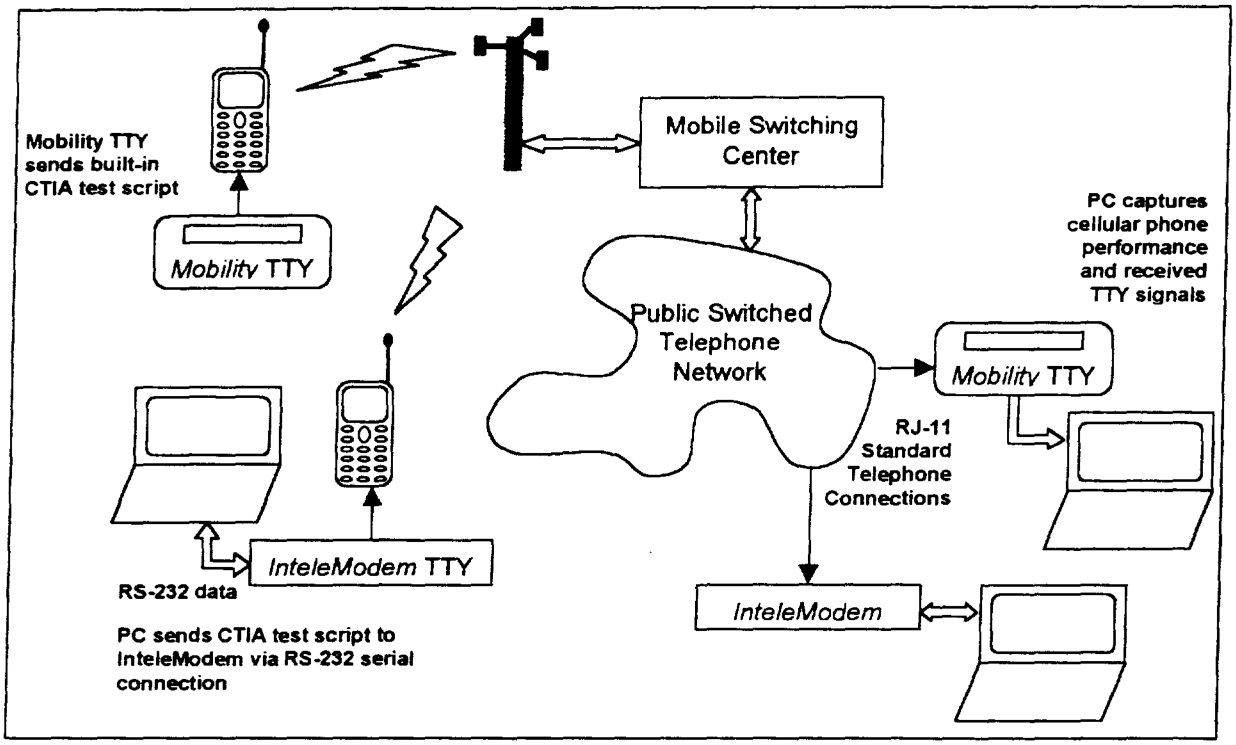

Figure 2.2-1 Test Setup – Reverse Audio Path

An audio path is established – using either a digital or analog voice channel – and the sending TTY transmits 45.45 baud baudot TTY characters per the CTIA published test script shown in Appendix A. The *Mobility* TTY unit can be put into a test mode whereby it transmits the CTIA script automatically. The *Intele-Modem* must be connected to a PC, and the test script sent to it using a terminal emulation program. The original CTIA script was used since when these data collects began, the *Mobility* TTY units in our possession only supported the old script. Also, the old script is preferable since it contains a portion of plain text which allows the tester to recognize failures.

The receiving TTY receives the data and transmits it to a lap-top PC using an RS-232 serial data connection. A PC connected to the receive TTY unit captures the received text using the *HyperTerminal* program. The Aeon phone's own antenna was used and was extended.

Each possible combination of these four operational scenarios discussed in section 2.1 were set up, and data captured. "Half rate" transmission can be selected in the *Mobility*'s test mode. To send half rate on the *Intele-Modem*, PCC wrote a special terminal emulation program that sends characters from the PC to the *Intele-Modem* at a user-selectable rate. There is an important difference between how the *Mobility* and *Intele-Modem* send "half rate": the *Mobility* keeps the "space" tone active during the pause, while the *Intele-Modem* removes both tones during the pause.

Received text files were assessed using the "score" program provided by Lober & Walsh. This program is fed a file with the known true text (shown in Appendix A), and the received text file. It correlates the two files and determines the error rate, as well as the number of characters: sent, correctly received, added, missing, and changed. The error rate equals the number missing or changed divided by the total number. The score program considers *all* characters corrupted by letters/figures shift problems to be errors.

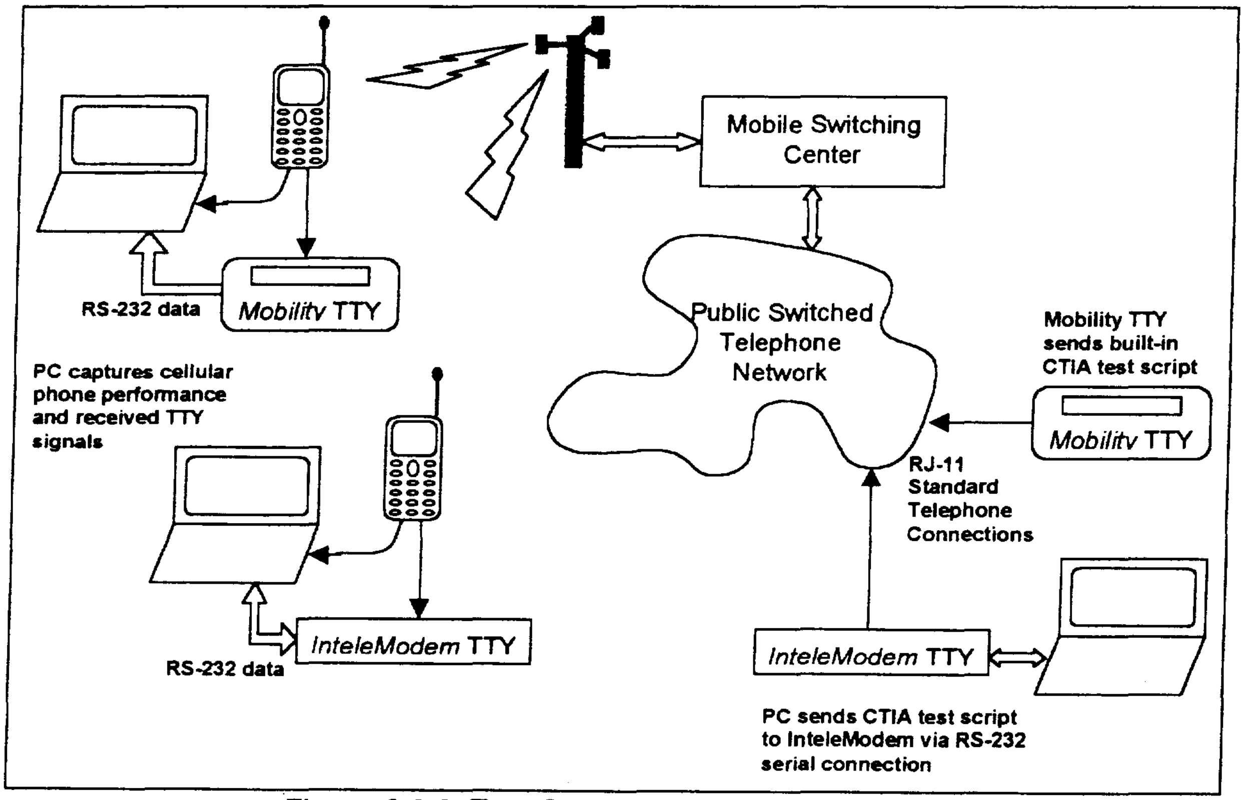

Figure 2.2-2 Test Setup – Forward Audio Path

A problem was discovered in the interpretation and scoring of carriage returns and line feeds. Different TTY devices seem to add these characters by themselves or translate them in various ways. To ensure consistent and fair results, Lober & Walsh created a version of the "score" program (time date stamp "8bc32521", 66667 bytes, signature "00004550") that ignores all carriage returns and line feeds, which we used to generate the results shown in this report.

A second version of the score program (time date stamp "8325252b", 69675 bytes, signature "00004550") has been created to calculate "character error rate" in two ways:

- Include errors that propagate after a shift error (this is the original method). Lober & Walsh refer to this as the "Text Match" method.

- Do not include errors that propagate after a shift error.). Lober & Walsh refer to this as the "Baudot Match" method. This method yields a "pure" character error rate whereby all character errors are given equal weight. This method produces results that are inherently less noisy, but do not reflect the reality of Baudot -- which is that letters/figures shift errors are a real problem.

Results using both calculation methods are shown below.

A proprietary PCC program is used to configure the Aeon phone (for example to force it to use either a digital or analog voice channel), and to capture performance information such as Received Signal Strength Indication (RSSI), Bit Error Rate (BER), and channel number to a file during test calls. Later, these files are processed to characterize cellular performance.

2.3 Required Equipment

Table 2.3-1 lists the required equipment.

Quantity	Equipment
1	*Aeon* IS-136 Cellular Telephone, with valid subscription on an IS-136 capable network
1	Aeon interface cable (includes audio in, audio out, and data)
2	Lober & Walsh *Mobility* TTY device
2	Ultratec *Intele-Modem* TTY device (one unit specially modified to facilitate audio connection to a cellular phone, per instructions provided by Ultratec)
1	Custom interface cable for interconnecting Aeon interface cable audio in and out (BNC connectors) with the *Mobility* TTY RJ-45 jack.
1	Custom interface cable for interconnecting Aeon interface cable audio in and out (BNC connectors) with the *Intele-Modem*.
1	Standard POTs phone line
2	Lap-top PCs (one with a PCMCIA serial adaptor for a 2nd serial port)
	Custom terminal emulation software for sending "half rate", available from PCC
	Score.exe program, available from Lober & Walsh
	CTIA published test script file (text shown in Appendix A)

Table 2.3-1. Required Equipment

3. Test Results

Table 3.1 and Table 3.2 show results matrices, organized by operational scenario. Table 3.1 results include shift errors, while Table 3.2 results do not, and thus reflect the true character error rate.

		Land: *Mobility* Cell: *Mobility*		Land: *Intele-Modem* Cell: *Mobility*		Land: *Mobility* Cell: *Intele-Modem*		Land: *Intele-Modem* Cell: *Intele-Modem*	
		forward	reverse	forward	reverse	forward	reverse	forward	reverse
		M (land) ↓ M (cell)	M (cell) ↓ M (land)	I (land) ↓ M (cell)	M (cell) ↓ I (land)	M (land) ↓ I (cell)	I (cell) ↓ M (land)	I (land) ↓ I (cell)	I (cell) ↓ I (land)
digital	full rate	7 1.1%	10/17 5.6%	15 12.0%	35 0.7%	1 1.6%	21 24.4%	26 3.0%	23 0.7%
digital	half rate	8 0.5%	9 2.4%	16 27.3%	36 0.7%	2 0.7%	22 6.1%	25 2.2%	24 5.8%
analog	full rate	5 2.0%	11 0.0%	13 0.3%	33 0.3%	3/18 2.2%	19 6.4%	27 0.6%	29/31 0.7%
analog	half rate	6 2.4%	12 0.0%	14 1.4%	34 0.2%	4 1.2%	20 9.0%	28 0.3%	30/32 0.4%

Table 3-1 Results Matrix -- *Including Shift Errors*

		Land: *Mobility* Cell: *Mobility*		Land: *Intele-Modem* Cell: *Mobility*		Land: *Mobility* Cell: *Intele-Modem*		Land: *Intele-Modem* Cell: *Intele-Modem*	
		forward	reverse	forward	reverse	forward	reverse	forward	reverse
		M (land) ↓ M (cell)	M (cell) ↓ M (land)	I (land) ↓ M (cell)	M (cell) ↓ I (land)	M (land) ↓ I (cell)	I (cell) ↓ M (land)	I (land) ↓ I (cell)	I (cell) ↓ I (land)
digital	full rate	7 0.5%	10/17 2.6%	15 6.6%	35 0.5%	1 1.2%	21 13.9%	26 1.5%	23 0.5%
digital	half rate	8 0.2%	9 1.3%	16 16.4%	36 0.5%	2 0.6%	22 2.6%	25 1.3%	24 2.8%
analog	full rate	5 0.9%	11 0.0%	13 0.3%	33 0.2%	3/18 1.3%	19 5.1%	27 0.4%	29/31 0.5%
analog	half rate	6 1.2%	12 0.0%	14 0.9%	34 0.1%	4 0.6%	20 3.1%	28 0.2%	30/32 0.2%

Table 3-2 Results Matrix -- *NOT Including Shift Errors (true character error rate)*

The column indicates "TTY device type and position" and "direction of communication". The row indicates "cellular voice channel type" and "transmission rate". Each matrix element shows the data collect number in blue, and the average *character error rate* for all data collected of that permutation. Complete results are shown in Appendix B.

In general, performance is relatively good -- averaging 2 or 3 per cent on digital channels -- when two similar TTY devices are communicating with each other (a *Mobility* with a *Mobility*, or an *Intele-Modem* with an *Intele-Modem*). However, when an *Intele-Modem* sends to a *Mobility*, performance falls off sharply. Lober & Walsh engineers believe this is due to audio level inconsistencies between the two devices, although this is unconfirmed. Curiously, performance results when a *Mobility* sends to an *Intele-Modem* are some of the best seen.

As expected, analog voice channel performance is generally better then digital voice channel performance. There is no discernible difference between "half rate" and "full rate" on analog voice channels. However on digital channels, "half rate" seems to improve performance when the *Mobility* is sending -- probably due to the way the *Mobility* maintains the "space" tone during pauses.

Shift errors clearly play a big part in TTY errors. Nearly every collect taken shows much worse results when shift errors are included. This is particularly true when a TDMA digital channel is used.

Several data collects were repeated when the data seemed anomalous. Often, the results diverged even though all factors under the tester's control were identical. For example, collect numbers 10 and 17 were taken in identical conditions (the phone wasn't even moved!), yet collect 17 scored 3.7 per cent and collect 10 scored 7.5 per cent -- over double the character error rate. No difference was seen in the cell phone's received signal strength or bit error rate for these collects, suggesting factors such as cellular system load were not an issue. Clearly, field data is just "noisy".

Time was not available to perform the volume of testing necessary to average out the "noise" inherent with field data. Too many results-influencing factors are unknown to, and beyond the control of, the field tester. Thus, field testing is a great way to get a feel for typical performance, and is the ultimate reality check, but it is not the way to obtain reproducible, consistent results!

3.1 Cellular Conditions During Testing

Table 3.1-1 shows the received signal strength distribution observed during all testing. Signal strengths were typically in the -75 to -80 dBm range when using digital traffic channels, and -75 to -85 dBm when using analog voice channels -- typical values for the well engineered BACTC network. Digital traffic channel bit error rates were 0.01 per cent or less, over 99 per cent of the time.

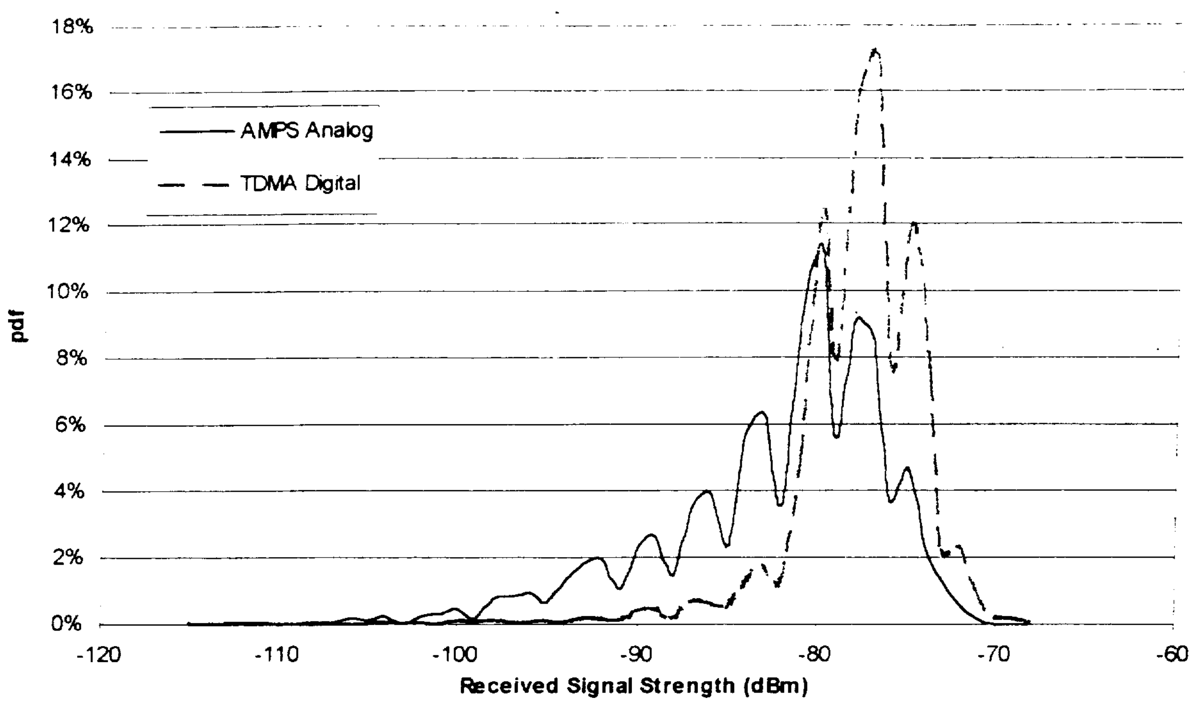

Figure 3.1-1 Distribution of Received Signal Strength for Digital and Analog Channels

3.2 Failure Modes

Three perceptible failure modes were noticed when analyzing results:

- isolated character errors
- letters/figures shift error blocks
- character alignment error blocks

The actual cause of individual character errors was not determined in this testing. However, what is clear is that these single errors trigger shift error blocks and character alignment error blocks, which then cause the majority of character errors.

When either a "letters" or "figures" shift character is corrupted, all subsequent characters are displayed in the wrong mode until the next shift character is correctly received, causing a "block" of errors. This failure mode, inherent to Baudot code, was observed frequently during testing. Appendix B lists each such occurrence, and gives the approximate size of each block.

Character alignment errors occur when the demodulator looses its reference to the beginning of a character. This is most typically observed when a sequence of repeated characters is transmitted -- such as the dashes in the CTIA script -- where a block of errors will propagate. While this failure mode is more likely to be recognized for a sequence of repeated characters, it undoubtedly occurs at other times as well, it is just less recognizable and may only affect smaller blocks. The character alignment method used in TTY transmission comes from the wired serial communications world, and is inherently weak as a method of acquiring and maintaining character alignment in a high error rate, radio environment.

No character alignment errors were observed when the *Mobility* was sending at "half rate" -- probably since the *Mobility* transmits the "space" tone during the pauses, which helps the receiving demodulator reacquire character alignment. The *Intele-Modem* had no such benefit.

4. Conclusions

Testing was performed using the Philips *Aeon* IS-136, TDMA digital cellular telephone with the Lober & Walsh *Mobility* and Ultratec *Intele-Modem* TTY devices in a typical, *stationary* location. Goals of this test were to determine how well different TTY devices interoperate in a cellular environment, determine if sending characters at a slower rate ("half rate") performs differently then at "full rate", and baseline digital performance against analog performance. Conclusions are as follows:

- *When communicating between like TTY devices*, on digital TDMA channels, character error rates averaged about **2 to 3 per cent**. Performance over analog channels averaged about **1 per cent**. Both TTY devices performed equally well.
- Performance degraded sharply when communicating from an *Intele-Modem* to a *Mobility*. Interestingly, when communicating from a *Mobility* to an *Intele-Modem*, performance was good. Inconsistent audio level requirements between the TTY devices may be causing these increased errors. ***PCC recommends that the TTY Forum focus on audio level standardisation at the TTY/cellular phone interface.***
- Sending characters at a slower rate ("half rate") seemed to improve performance slightly when the "space" tone was maintained during the pauses. Maintaining the "space" tone may be reducing the number of character alignment errors.
- The blocks of incorrectly interpreted characters that result from isolated Shift errors play a big part in high TTY character errors rates, particularly on digital channels. Replacing Baudot with a modern character set would improvement performance significantly.
- Field testing is a great way to get a feel for real-life conditions, and is the ultimate reality check, but field data is "noisy"! Field conditions do not allow the control needed to produce consistent, repeatable data, and thus care must be taken how field data is used.
- For testing requiring consistent, repeatable results, lab testing is needed. PCC recommends that these TTY testing techniques be adapted for use at high quality cellular labs. Such labs exist at the facilities of handset and infrastructure manufacturers, some cellular system operators, and at CTIA's certification facility in Lexington Kentucky.

PCC sincerely thanks Joshua Lober of Lober & Walsh Engineering and Ron Schultz of Ultratec for their help during these tests.

Appendix A – CTIA published test script

```
THE FOLLOWING FILE IS FOR TESTING TTY ERROR RATES.
THE NEXT 28 LINES ARE RANDOMLY GENERATED CHARACTERS:
"!"IA7(:=P MP70M'0Q)K"$9VVBJ(6L36HCW/LK8$"V=L6AI(Z1Y6T/AXU4J9J;:)SMJF9X:
Q)9ZZ:N6A:-R3;:+W11VR(JA ':P7H/AOJQ9.WI( 38 W2'513UHO/;WBC 9K7-RFW)Q/62?
?R549I4EO9"LVIRS H-3VTWE90L7G3D,68W=EHZP:P7 ==0P;87(B:!5Z0W(ORX!I?,/ 8"R
(GD"J-BMLJSA Q7=BH9!MD"KUZ$M!!IX;DOU8B?.F CBDILR +K4O4()ONO.EP!XY6258G,7
3=CGOR3?.Y/VKMSP8787QYB=8,E'G9UA'I!?6;0L ORT!!7GU:3)?:22/:0CQNP3D$0W4Y1W
09B=CXP$-$:M1RKBK+BF1/+. YO(:LT6M 5NS6LH R.28 RK?S?VHS6QD:FC+F1GY)UEY-X,
9A0(K),E4)O'BZD:/SG2.5XVL:G2K:9'("YN1QI20OCIVVYC.BSU7C8Y3BP)$LLD".2RJ0NJ
;.3)M;+P1=9?X(FJTN?FLHJ 2FT"7J.,JNBZR AG$B!061+XDN 2QYWDESO2AY8Y.-:36)8J
4QHK5:4T7HSW! $2F5YV9PO8XD- 6187TZ'BMX;U5/)Z(,FE/MJ-L0RR"K-$.7IN?$R8+I!.
K,$NXG;3I (!8OX,JMG;Q39 ?J!/R.CBD$9YK :XYUN.WIN(I.G/$ D,="Y T$6;; 4ZB$UF
BD)L3YL/19?7ION9GUUBGPJXIH-;C!57R (ZT1+.,4SD/QZ:7+0X$QV,VTOIL8GC$H79" !P
(F=4GYI;B ,OHO3+D956 +=A=SB+A/;L4PZC7C!T3D:WMF'L BK62/2I0V6NVI-9$ GRW(U4
;2'RSP77$A.9M(07+N;N=,I VR."OV+!I+  MDJN= 462H??SEI/+8'B'(R'!D="'2WX'.PR
V).3QJS3'QS1/CW+12E+!7+,DD4U$G HI"(EKZ1/F1T:28+K)1CN++KPW8;O0XD$R9J.6B'
 E9 KF'ZWILK1ECDP)4W 3MYA8!B!W7R';BVY/?K  T""/.4KHO)1P F"R$WM7D.331U,IG-
JI;7"H;MU!I2X0P;BPJTIIGO4Q5V/ 5BBBWQLRMIPI48AN/NX/X0;4YT,C:"5.4 .3:AALLS
IGD08INPF4QLLD9J)GW2C:/.:"-9)V,DJS$9KP$;5(=+I71Q'HL+SLP3A;Y?!  D1ZLJ8B9!
9ZN(;W(RH/ 6KVAWUKQ3S;KLH-VFUMK+:8)8A,H+T.440!PEF/"8.TW"F VZ73$IRL295JNK
,SVMSL?NG1)LQ6Y"YNM1Z,S+26,D+;XI!-=K/YG" SRP0W"+'E581$4WA 1G2)6FEL4Y$O S
?$;(7-/24=U9HIOT9/'SH:TOKB45IPI2J"IHS.GE, !D 62!.=7!/VQJT".HO//UH(41.7!=
MU4UCW/QNL3AP+RSHW'LHK'J='"PQZZ?P$R09!DX+;I !O!$ULN60Z0W9DXVL!A05$RCKX 8
W5+"Z7)Q W'R+E06YFV;;)8 ,$XAZ-EWO 8P)-G+X/4MXF.0N6+40UHW5E7P8E7E34MQ5A.I
 UA:FBA0Q"AQ?="I:5/IRDG1RRN2CE/4SPXQ(W(M$SC)V-Y/YDU3LF?57,59V+8NR3X/'=!K
RHPWIYR,4OZL!8L=H"UJU$X="0":2E,W L5EC F30Y$38C;FS,7?X1RJE)'S8BO5L/ZR8T4M
7HNHD'=DKSC'7/ A2;F7G !BBCL2P(7NQXCPVN6.ZWR,O6L=:M2-M=4?HB)M"3LD)$6VY(9O
-);A27J$608416Y?34GF+F,?(T4R"KB$F!;2?4S6?2L.,C"K4W4P/(2HZ AMUZSPZ-W3'QR=
 L7ZL! W6O3/"UGT-JNH?!S B/))HB6ANYUR?/X;:269D1FFAN9K;!?'P$4BE$,WOOL7/MIE
?$ONDK:I7?0 P3!R!V)"(7O$FH$:L O..SJ."7OFR M" (:36Q=OL1PL:XD)L/6A.O  =TTG
```

NOW STARTS SEVERAL LINES OF PLAIN TEXT TEST EXAMPLE EMERGENCY MESSAGES:

A TYPICAL POLICE-TYPE CALL

911: POLICE AND FIRE

CALLER: I NEED THE POLICE SENT RIGHT AWAY

911: OK, FIRST OF ALL, WHAT IS YOUR ADDRESS?

CALLER: 7101 YATES AVENUE NORTH, BROOKLYN PARK

911: OK, 7101 YATES AVENUE, WHAT'S GOING ON THERE?

CALLER: I THINK I HEAR SOMEONE IN MY BASEMENT

911: IF YOU CAN LOCK YOURSELF IN A BEDROOM, DO SO NOW. I'M GOING TO DISPATCH THE POLICE NOW, SO STAY ON THE PHONE WITH ME AND DO NOT HANG UP

CALLER: OK

911: POLICE ARE ON THE WAY, ARE YOU HEARING ANY NOISES NOW? DO YOU HAVE ANY FAMILY MEMBERS THAT MAY BE DOWN THERE?

CALLER: I'M NOT HEARING ANYTHING NOW.. AND NO, I LIVE ALONE.

911: OK, I'M GOING TO KEEP YOU ON THE PHONE WITH ME UNTIL THE POLICE ARRIVE

A TYPICAL EMS-TYPE CALL

911: POLICE AND FIRE

CALLER: I NEED AN AMBULANCE SENT RIGHT AWAY FOR MY HUSBAND

911: OK, WHAT IS YOUR ADDRESS?

CALLER: 6825 HUMBOLDT AVENUE, CHAMPLIN

911: OK, 6825 HUMBOLDT AVENUE, CHAMPLIN, WHAT IS WRONG WITH YOUR HUSBAND?

CALLER: HE IS HAVING CHEST PAINS

911: DOES HE HAVE A HISTORY OF HEART PROBLEMS?

CALLER: NO

911: OK, HAVE HIM SIT DOWN, KEEP HIM CALM. TURN YOUR OUTSIDE LIGHT ON SO WE CAN SPOT YOUR HOUSE FASTER. I AM SENDING AN AMBULANCE AND POLICE.

A TYPICAL FIRE-TYPE CALL

911: POLICE AND FIRE

CALLER: I WANT TO REPORT A FIRE

911: WHAT IS YOUR ADDRESS?

CALLER: 1901 DUPONT AVENUE, PLYMOUTH

911: OK, 1901 DUPONT AVENUE, PLYMOUTH. WHAT IS ON FIRE?

CALLER: MY GARAGE

911: IS THE GARAGE ATTACHED TO THE HOUSE?

CALLER: YES

911: OK, I NEED YOU TO HAVE EVERYONE GET OUT OF THE HOUSE AND GO ACROSS THE STREET AND WAIT FOR FIRE AND POLICE TO ARRIVE.

END OF TEST SCRIPT

Appendix B – Test Data

No.	Date	Source TTY Device	Source Phone	Destination TTY Device	Dest. Phone	Analog/ Digital	Full / Half	Error Description	Error Rate (Text Match)	Error Rate (Baudot Match)
1	7/29/98	*Mobility*	land	*Intele-Modem*	Aeon	digital	Full	scattered errors	**1.55%**	**1.16%**
2	7/29/98	*Mobility*	land	*Intele-Modem*	Aeon	digital	Half	scattered errors	**0.74%**	**0.56%**
3	7/29/98	*Mobility*	land	*Intele-Modem*	Aeon	analog	Full	one large char alignment error propagation block, several L/F blocks	**4.24%**	**2.54%**
4	7/29/98	*Mobility*	land	*Intele-Modem*	Aeon	analog	Half	scattered errors. one medium L/F block	**1.18%**	**0.60%**
5	7/29/98	*Mobility*	land	*Mobility*	Aeon	analog	Full	scattered errors. two medium L/F blocks	**1.97%**	**0.93%**
6	7/29/98	*Mobility*	land	*Mobility*	Aeon	analog	Half	scattered errors. two medium and one small L/F blocks	**2.39%**	**1.23%**
7	7/29/98	*Mobility*	land	*Mobility*	Aeon	digital	Full	scattered errors. one medium L/F block	**1.13%**	**0.48%**
8	7/29/98	*Mobility*	land	*Mobility*	Aeon	digital	Half	scattered errors. one small L/F block	**0.54%**	**0.15%**
9	7/30/98	*Mobility*	Aeon	*Mobility*	land	digital	Half	scattered errors. one small L/F block	**2.42%**	**1.34%**
10	7/30/98	*Mobility*	Aeon	*Mobility*	land	digital	Full	one large char alignment error propagation block, several L/F blocks. scattered errors	**7.54%**	**3.46%**
11	7/30/98	*Mobility*	Aeon	*Mobility*	land	analog	Full	no errors!	**0.00%**	**0.00%**
12	7/30/98	*Mobility*	Aeon	*Mobility*	land	analog	Half	no errors!	**0.00%**	**0.00%**
13	7/30/98	*Intele-Modem*	land	*Mobility*	Aeon	analog	Full	small, isolated errors.	**0.32%**	**0.25%**
14	7/30/98	*Intele-Modem*	land	*Mobility*	Aeon	analog	Half	scattered errors. one small L/F block	1.43%	0.93%
15	7/30/98	*Intele-Modem*	land	*Mobility*	Aeon	digital	Full	scattered errors plus two large and one small L/F blocks	12.03%	6.62%
16	7/30/98	*Intele-Modem*	land	*Mobility*	Aeon	digital	Half	errors everywhere. Plenty of L/F and character alignment propagation error blocks.	27.27%	16.40%
17	7/30/98	*Mobility*	Aeon	*Mobility*	land	digital	Full	one small char alignment error propagation block, and two medium L/F blocks	3.67%	1.75%
18	7/30/98	*Mobility*	land	*Intele-Modem*	Aeon	analog	Full	one small L/F block	0.10%	0.08%
19	7/30/98	*Intele-Modem*	Aeon	*Mobility*	land	analog	Full	scattered errors plus one big block where most, but not all, characters are just missing	6.39%	5.06%
20	7/30/98	*Intele-Modem*	Aeon	*Mobility*	land	analog	Half	scattered errors, plus one large and two medium L/F blocks	**8.95%**	3.12%
21	7/30/98	*Intele-Modem*	Aeon	*Mobility*	land	digital	Full	L/F errors all over the place!	**24.41%**	**13.88%**
22	7/30/98	*Intele-Modem*	Aeon	*Mobility*	land	digital	Half	scattered errors plus numerous small and one large L/F blocks	**6.12%**	**2.60%**
23	7/30/98	*Intele-Modem*	Aeon	*Intele-Modem*	land	digital	Full	scattered errors plus one small L/F block	**0.74%**	**0.54%**

24	7/30/98	*Intele-Modem*	Aeon	*Intele-Modem*	land	digital	Half	scattered errors plus one large char alignment error propagation block -- a row of "-" became a row of "A"	5.84%	2.75%
25	7/30/98	*Intele-Modem*	land	*Intele-Modem*	Aeon	digital	Half	scattered errors plus 3 small and one medium L/F blocks	2.19%	1.25%
26	7/30/98	*Intele-Modem*	land	*Intele-Modem*	Aeon	digital	Full	scattered errors plus one medium L/F block	3.00%	1.49%
27	8/26/98	*Intele-Modem*	land	*Intele-Modem*	Aeon	analog	Full	scattered errors plus one small L/F block	0.56%	0.43%
28	8/26/98	*Intele-Modem*	land	*Intele-Modem*	Aeon	analog	Half	scattered errors	0.30%	0.23%
29	8/26/98	*Intele-Modem*	Aeon	*Intele-Modem*	land	analog	Full	scattered errors	0.35%	0.25%
30	8/26/98	*Intele-Modem*	Aeon	*Intele-Modem*	land	analog	Half	no perceptible errors.	0.20%	0.14%
31	8/26/98	*Intele-Modem*	Aeon	*Mobility*	land	analog	Full	scattered errors plus 3 small L/F blocks	0.97%	0.68%
32	8/26/98	*Intele-Modem*	Aeon	*Mobility*	land	analog	Half	scattered errors plus one small L/F block	0.54%	0.21%
33	8/26/98	*Mobility*	Aeon	*Intele-Modem*	land	analog	Full	scattered errors	0.30%	0.21%
34	8/26/98	*Mobility*	Aeon	*Intele-Modem*	land	analog	Half	scattered errors	0.23%	0.09%
35	8/26/98	*Mobility*	Aeon	*Intele-Modem*	land	digital	Full	scattered errors plus one or two very small L/F blocks	0.73%	0.61%
36	8/26/98	*Mobility*	Aeon	*Intele-Modem*	land	digital	Half	scattered errors	0.73%	0.45%

Error Block Size Key:

small error blocks	< 8 characters
medium error blocks	8 - 20 characters
large error blocks	> 20 characters

APPENDIX J

Electronic Industries Association

May 16, 1988

TO: PARTIES INTERESTED IN EIA STANDARDS PROJECT PN 1663, TELECOMMUNICATIONS DEVICES FOR THE DEAF

In 1981, EIA Engineering Committee TR-41 undertook the writing of a voluntary industry standard for telecommunications devices for the deaf. Our intent at that time was to originate a standard which would provide compatibility and minimum performance criteria for these specialized devices. This effort was considered to be in the public interest both for the purpose of ensuring interoperability of TDDs and to optimize TDD operation on the Public Switched Telephone Network (PSTN).

As commercial interest in these devices has diminished, we now find ourselves in a situation where only two manufacturers remain in the market, and they seem unwilling or unable to agree on the terms of the standard. There has been no movement on this standard project since June of 1986. Accordingly at its March 1988 meeting, TR-41 voted to abandon PN 1663 and directed me to place the existing document, Draft 9, in the public domain and to make it available to any parties wishing to attempt to continue the effort. EIA and its successor organizations will no longer maintain this draft, but will continue to make copies available to qualified persons and organizations for a reasonable period of time. A copy of Draft 9 is enclosed with this letter.

We also have on file copies of Draft 1 (21 pp), Draft 4 (28 pp), and Draft 8 (54 pp) which may be studied by appointment at our offices or which can be photocopied and sent to you at a charge of $ .10 per page. Requests for these copies may be directed to me at:

Telecommunications Industry Association
Suite 4040
1722 Eye Street, NW
Washington, DC 20006
Phone: 202/457-4936
FAX : 202/457-4939

Sincerely,

Peter H. Bennett
Vice President
Telecommunications Industry Association

Enclosure

~~EIA~~ STANDARDS PROJECT PN-1663

TELECOMMUNICATIONS DEVICES

FOR THE DEAF

DRAFT 9

JUNE, 1986

NOTE:

| Indicates new or revised material

Indicates item still under discussion

Prepared by the EIA Engineering Committee TR-41

Ad Hoc Committee on Telecommunications Devices
for the Deaf

NOTICE

~~EIA Engineering Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such standards and publications shall not in any respect preclude any member or non-member of EIA from manufacturing or selling products not conforming to such standards and publications, nor shall the existence of such standards and publications preclude their voluntary use by other than EIA members, whether the standard is to be used either domestically or internationally.~~

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NOTICE

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TELECOMMUNICATIONS DEVICES FOR THE DEAF

(From EIA Project Number No. 1663, formulated under the cognizance of EIA TR-41 Committee on Telephone Terminals)

1. INTRODUCTION

~~1.1 This standard is one of a series of technical standards on telephone terminal equipment issued under the auspices of EIA Engineering Committee TR-41. It has been prepared by an ad hoc committee of manufacturers of Telecommunications Devices for the Deaf (TDDs), representatives of users of these devices, and representatives of the telephone industry, operating under the cognizance of EIA TR-41 Committee on Telephone Terminals. Formation of the ad hoc committee was jointly sponsored by EIA's Telephone Equipment Section and Telecommunications for the Deaf, Inc., Silver Spring, Maryland. This document fills a recognized need in industry brought about by the accelerating trend to replace electromechanical teletypewriters by portable electronic devices as a means by which hearing- or speech-impaired persons may make beneficial use of the public telephone network. It will be useful to anyone engaged in the manufacture of telecommunications devices for the deaf and to those purchasing, operating or using such equipment or devices.~~

1.2 The standard establishes performance and compatibility requirements for the interoperation of TDDs with a dial-up public or private-line telephone network connection as the transmission medium. As such, it has been necessary in some cases to make compromises between optimum conditions for the operation of the devices and the need for the public telephone network to carry these signals without interference to other users.

1.3 In accordance with EIA Engineering Publication EP-7, two categories of performance standards are specified, mandatory and advisory. The mandatory performance criteria are designated by the word "shall" and the advisory criteria by the words "should", "may", or "desirable" (which are used interchangeably in this standard). The mandatory criteria generally apply to safety, protection, signaling, and compatibility. They specify the absolute minimum acceptable performance levels in areas such as transmission and equipment parameters and durability.

1.4 Advisory or desirable criteria represent product goals. In some instances, these criteria are included in an effort to assure universal product compatibility with equipment and facilities operational in statistically small quantities. In other cases, advisory criteria are presented when their attainment will enhance the general performance of the product in all its contemplated applications. Where both a mandatory and an advisory level are specified for the same criterion, the advisory level represents a goal currently identifiable as having distinct compatability advantages, performance advantages, or both, toward which future designs should strive.

1.5 As technology and application engineering techniques advance, the criteria contained in this document will become subject to change. Furthermore, the document is intended to be a living document, subject to revision and updating, as warranted by advances in network and equipment technology and design.

2. SCOPE

2.1 This standard defines the minimum signaling, protocol, and interface requirements necessary for the successful interoperation, through the switched telephone network, of TDDs and specialized modems intended for use with teletypewriters in networks providing interactive communications for hearing- and speech-impaired persons. These networks are characterized by the use of five-level Baudot code at a nominal speed of 45 baud, half-duplex transmission, and tone frequency conventions of 1400 Hz for mark and 1800 Hz for space.1/

In addition, this standard provides criteria for the signaling, protocol, interface, and keyboard content of TDD equipment which provides optional operation using ASCII seven level codes and "Bell 103" compatible frequencies. The criteria are applicable, however, only when applied to a TDD product which also provides Baudot operation as described above.

2.2 This standard covers TDD'S intended for use with telephones meeting the requirements of RS-470, Telephone Instruments for Voiceband Applications (Ref: A1). Criteria are provided for devices using acoustic coupling to the telephone handset and for devices connected to the telephone line in parallel with the telephone. Acoustic coupling criteria are based on the handsets used with 500-type or similar telephones and may not provide for coupling to "decorator" type telephones.

2.3 Other arrangements are possible but are not covered by this standard.

2.4 This standard does not apply to terminals intended for other communications such as "electronic mail" terminals.

1/ It is recognized that the 5-level Baudot code employed is not the code of choice for new communications networks and that 45 baud operation does not efficiently utilize the capabilities of a voice grade telephone connection. The use of the Baudot code at this rate in conjunction with modems using 1400 and 1800 Hz is widespread by hearing- and speech-impaired persons presently using the telephone network and is described by Dr. Robert H. Weitbrecht in U.S. Patent RE27595. This TDD standard is not limited, however, to the specific protocols utilized by Dr. Weitbrecht.

2.5 Requirements in this standard designated by the parenthetical expression (REN) assume a Ringer Equivalence Number of 1.0. If the TDD has a REN other than 1.0, the stated requirements shall be scaled appropriately, consistent with the definition of REN given in Part 68 of the FCC Rules and Regulations (Ref: A2). Examples of the scaling procedure can be found in section 5.1 of the application notes in this standard.

2.6 This standard is intended to be in conformity with Part 68 of the FCC Rules and Regulations, but is not limited to the scope of those rules.

3. DEFINITIONS

This section contains definitions of terms needed for the proper understanding and application of this standard which are not believed to be adequately treated elsewhere. A glossary of telephone terminology, which will be published as a companion volume to the series of technical standards on Telephone Terminals, is recommended as a general reference and for definitions not covered in this section.

Acoustic Coupling

Acoustic coupling is a means of coupling a signal generated by auxiliary equipment to a dial-up public or private-line telephone network using the telephone handset as the network interface and an audio tone or tones for the transfer of information.

ASCII

ASCII is an acronym for American Standard Code for Information Interchange (Ref: A3). This standard defines the code for a character set to be used for information interchange between equipment of different manufacturers and is a standard for data communication over telephone lines.

Baudot Code

Baudot code is a code for the transmission of data in which five equal-length bits represent one character. This code is used in TDDs with one start bit and one or more stop bits added.

TDD

TDD is an abbreviation for Telecommunications Device for the Deaf. These devices are machines capable of information interchange between compatible units using dial up or private-line telephone network connections as the transmission medium. ASCII or Baudot codes are used by these units.

4. TECHNICAL REQUIREMENTS

TDDs shall provide for either acoustic coupling to a telephone handset or direct connection to the telephone line. Provision of both acoustic coupling and direct connection is permissable. When both are provided the TDD shall be arranged so that only one type of coupling is active at any given time.

4.1 Acoustic Coupling

[Requirements in Section 4.1 apply to TDDs which are acoustically coupled. See section 4.2 for requirements for direct coupled devices.]

TDDs provided with acoustic coupling may incorporate the acoustic coupler in the TDD unit or provide the coupler as a separate module. The coupler shall be designed to accept the handsets used with generic 500-type telephone sets.

4.1.1 Magnetic Coupling

The receiver of the acoustic coupler shall rely only on the acoustic signal from the handset. The magnetic field associated with the receiver of some handsets is not suitable for coupling.

4.1.2 Sidetone

TDDs employing acoustic coupling shall be arranged so that the sidetone provided by the telephone does not cause errors in the operation of the device.

4.1.3 Transmit Signal Levels

4.1.3.1 Requirements

The maximum transmitted signal level shall be -10 dBm$\pm$1dB for Baudot or ASCII answer operation. This requirement applies to the mark and space frequencies individually and to a 3 second average reading of a repeated test character string. The maximum transmitted signal level shall be -12 dBm$\pm$3dB for ASCII originate operation.

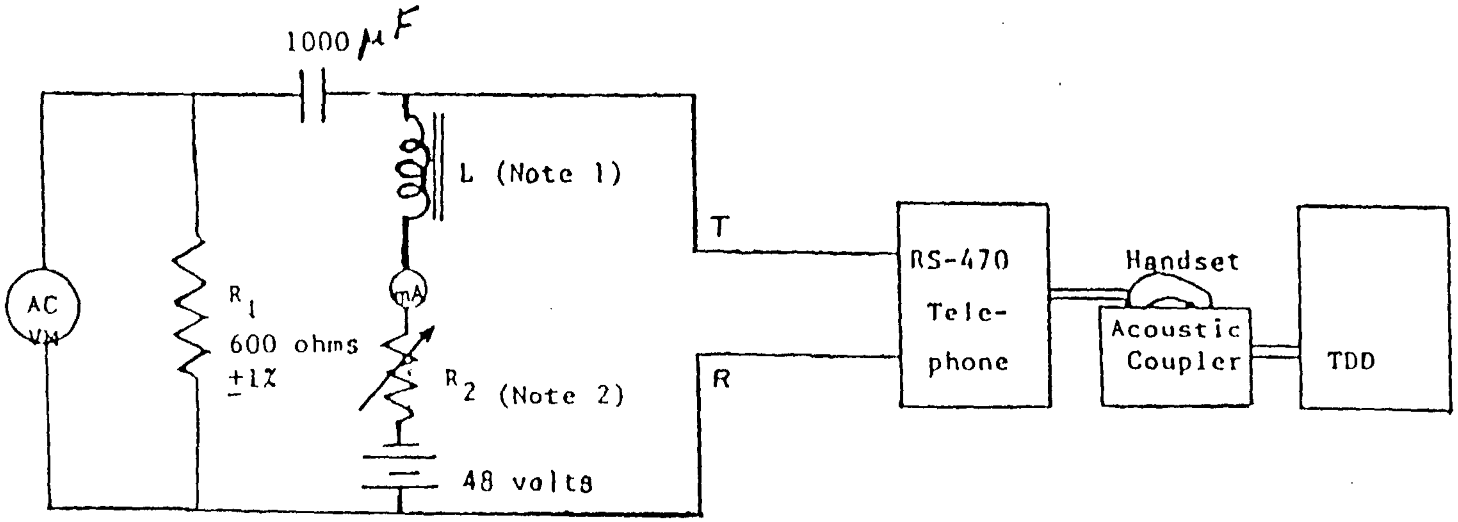
4.1.3.2 Method of Measurement

The transmit signal levels shall be measured using the circuit of Figure 1A with the loop current adjusted to 90 milliamperes. The test character string for Baudot code shall be the repeated characters R and Y. For ASCII code, it shall be repeated letter U. The test character strings provide alternating marks and spaces in the data bits. For ASCII code, test both originate and answer modes.

The telephone set used in the test circuit shall meet the requirments of EIA RS-470 and will have a transmit acoustic to electrical sensitivity at the six frequencies below determined by curve Figure 1B when 6 dB Pa is applied to the microphone:

1070 Hz	1800
1270	2025
1400	2225 Hz

Measurement results made using a calibrated telephone set not meeting these points shall be adjusted to reflect the difference.



Notes;

1. Inductance of battery feed coil, L, at maximum current must be at least 5 H and resistance must be less than 400 ohms.

2. R_2 plus the resistance of the battery feed coil must be adjustable from 400 to 1740 ohms.

3. ACVM shall be a high impedance meter.

FIGURE 1A TDD TO LINE TEST CONFIGURATION

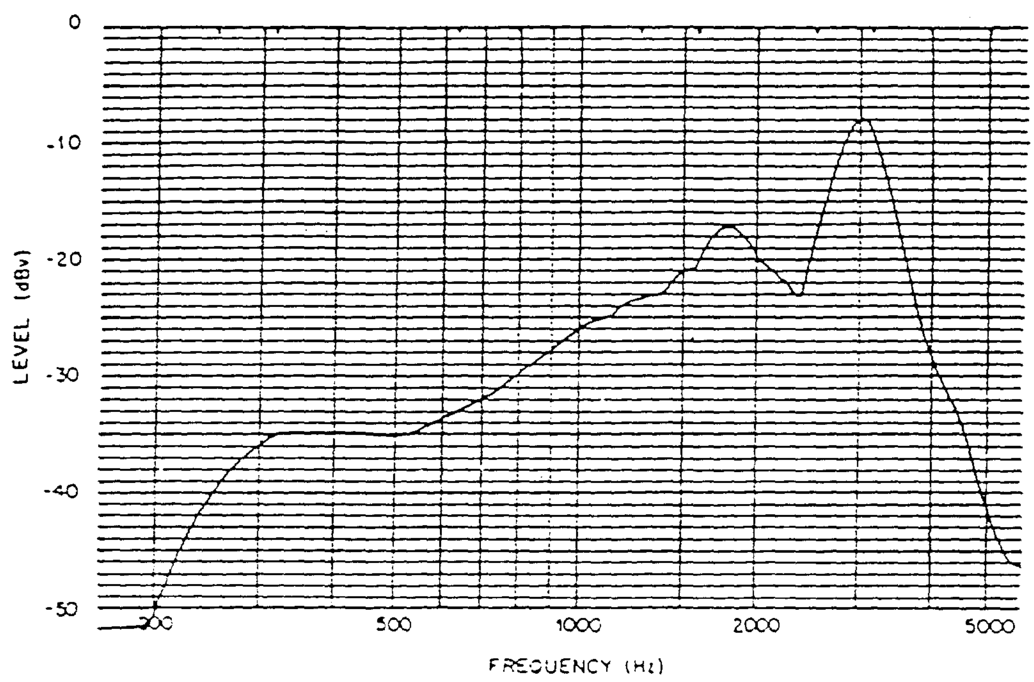


FIGURE 1B RESPONSE CURVE FOR STANDARD TELEPHONE

4.1.4 Receive Signal Levels

It should be noted that sensitivity levels better than those specified may cause unintended characters to be received during noisy idle line conditions. This may be aggravated by high impulse noise present on some telephone lines. It is desireable that sufficient noise immunity be designed into such receivers to prevent the TDD from printing and/or displaying spurious characters during these noise conditions.

The receive signal levels shall be tested using the test setup shown in Figure 2. The test telephone shall conform to the requirements of RS-470 (Ref: A1), and have a receive electrical to acoustic sensitivity at 1000 Hz of 17 dB Pa when 0 dBm is applied to the tip and ring. With the loop current adjusted to 90 ±1 milliamperes, the TDD shall correctly receive signals with levels from -5 dBm to -45 dBm with a signal to noise ratio of 13 dB or greater at the input to the telephone. The line noise shall be white noise as measured at the telephone tip and ring using C-message weighting. Verification shall consist of error free reception of the following message, or equivalent, for a minimum of 120 seconds in a environment with a room ambient noise intensity of 70 dBSPL.

THE QUICK BROWN FOX JUMPED OVER THE LAZY DOG
<FIGS> 123456789 <LTRS> TEST

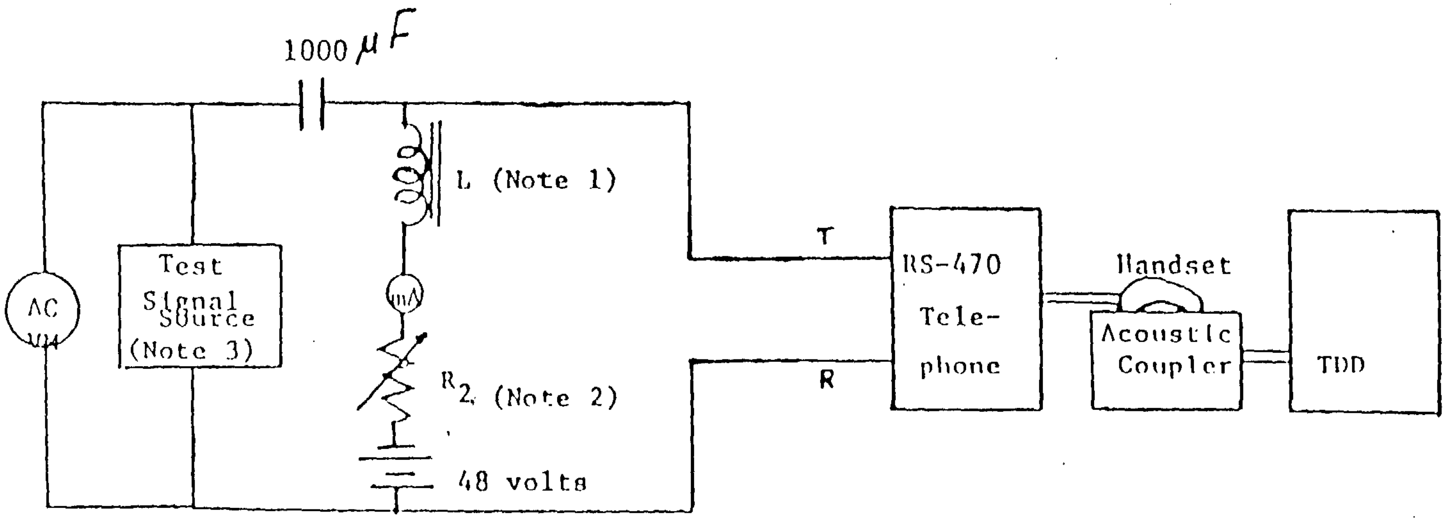
The <FIGS> and <LTRS> characters shall be omitted when testing ASCII code. For ASCII code, these levels shall apply to both the originate and answer modes.

4.1.5 Background Noise Suppression

The acoustic coupler shall be arranged so that background room noise of 70 dBSPL shall result in less than -40 dBm when measured with the test circuit of Figure 1A, with the loop current adjusted to 90 ±1 milliampere. This shall be measured with the TDD turned off.

4.1.6 TDD Noise

TDD noise with acoustic coupling is the internally-generated noise appearing at the acoustic output of the TDD. The noise shall not exceed -35 dBm when measured using the test arrangement of Figure 1A with the loop current adjusted to 90 ±1 milliamperes. The TDD noise should be measured with the TDD turned on but with no signal tones present. The measurement shall be taken over a minimum period of 5 seconds.



Notes:

1. Inductance of battery feed coil, L, at maximum current must be at least 5 H and resistance must be less than 400 ohms.

2. R_2 plus the resistance of the battery feed coil must be adjustable from 400 to 1740 ohms.

3. Test signal source should have an output impedance of 600 ohms $\pm 10\%$.

Figure 2 Test Configuration for Line to TDD

4.1.7 Signal Power Near 2600 Hz

Excessive signal power in the 2450 to 2750 Hz band in the absence of sufficient power in the 800 to 2450 Hz guard band can result in false disconnect or transmission interruption. The following requirement applies to all signals which the TDD may generate or cause to be generated (e.g., by a character sequence).

4.1.7.1 Method of Measurement

Measure the power transmitted by the TDD when acoustically coupled to a telephone set as shown in Figure 1A. Adjust the loop current to 90 ± 1 milliamperes. The power in the 2450 to 2750 Hz band shall (a) not exceed -50 dBm or (b) alternatively, be at least 14 dB below the power in the 800 to 2450 Hz band. These requirements shall not be exceeded for more than 40 milliseconds more often than once in 15 minutes and should not be exceeded for an interval greater than 150 milliseconds more often than once an hour.

It is desirable that the power in the 2450 to 2750 Hz band not exceed -40 dBm at any time.

Note: In demonstrating compliance, it is desirable that the 2450 to 2750 Hz band be defined by a bandpass filter having a 3 dB point (3dB loss relative to midband loss) at a frequency of 2450 Hz or lower and a 3 dB point at a frequency of 2750 Hz or higher. It is desirable that the 800 to 2450 Hz band be defined by a bandpass filter having a 3 dB point at a frequency of 800 Hz or higher and a 3 dB point at a frequency of 2450 Hz or lower. The midband loss of the filter defining the 2450 to 2750 Hz band shall be less than or equal to the midband loss of the filter defining the 800 to 2450 Hz band, when transmitting the test signal in 4.1.3.

4.2 Direct Connection

[Requirements in Section 4.2 apply to TDDs which are directly connected to the telephone network.]

TDDs designed for direct connection to the telephone line in parallel with a standard telephone shall meet the requirements of this section and all its subsections. The telephone shall be used for originating calls and providing an alerting signal on incoming calls. TDDs designed for direct connection to the telephone line without the use of a telephone in parallel shall meet the requirement of ANSI/EIA 496, Interface between Data Circuit-Terminating Equipment (DCE) and the Public Switched Telephone Network (Ref: A4) instead of the requirements of this section and its subsections.

4.2.1 Loop Supervision Characteristics

Supervisory signals are the means by which a TDD connected in parallel with a telephone answers, holds or releases a connection 2/ or recalls an operator. Since continuity of the dc loop current is not guaranteed, TDDs shall not depend on such continuity for proper operation. Loop current interruptions shall not cause a TDD to make a transition from one state to another.

The following are of interest in the supervision of the suscriber line by the TDD; 1) idle; 2) "talking"; and 3) disconnect.

4.2.1.1 Idle State

The idle state is characterized by the combination of an on-hook condition and the absence of a connection to the transmission path in the CO or PBX. The on-hook condition is defined by the on-hook dc resistance and ac impedance criteria specified in 4.2.2.

In this state no dc potential shall be transmitted from the TDD across the network interface.

4.2.1.2 "Talking" State

The "talking" state is characterized by the combination of an off-hook condition and a connection to a talking path in the CO or PBX. The off-hook condition is defined by the off-hook dc resistance and ac impedance criteria specified in 4.2.3.

While in this state, the TDD at a telephone which has originated a call shall not generate an on-hook signal longer than 100 milliseconds in duration, except to generate a disconnect or a flash signal. When the TDD generates a flash signal automatically, the duration of the on-hook signal shall be between 300 milliseconds and 1 second.

A TDD which has answered an incoming call shall not generate an on-hook signal longer than 10 seconds, except to generate a disconnect signal.

2/ The telephone is used with this arrangement for originating calls and may be used for answering calls. When the telephone is used for originating or answering calls that are then to be switched to the TDD, the TDD must be placed in the off-hook, or busy, state before the telephone is returned to the on-hook, or idle, state. In originating calls, the TDD must remain in the idle state until the completion of dialing.

4.2.1.3 Disconnect State

The disconnect state is characterized by an on-hook condition. The on-hook condition is defined by the on-hook dc resistance and ac impedance criteria specified in 4.2.2.

4.2.2 On-Hook Impedances

4.2.2.1 DC Resistance

The on-hook dc resistance is a measure of the idle loop current which the TDD draws from the CO or PBX. The limits are defined by Part 68 of the FCC Rules and Regulations for protection of the telephone network.

The on-hook dc resistance tip to ring, tip to ground, and ring to ground shall be greater than 25 megohms (REN) for values of applied dc voltage to 100 volts and greater than 150 kilohms (REN) in the range from 100 to 200 volts. These values shall apply to both polarities and with the TDD in both the power on and off states except that it shall apply only to the power off state if the TDD design does not allow the on-hook state with the power on.

4.2.2.1.1 Method of Measurement

Connect the TDD tip and ring conductors to a dc source, variable from 0 to 100 volts or from 100 to 200 volts as appropriate. Measure the minimum ratio of dc voltage and current for each voltage range with the TDD power both off and, if the TDD can be in the on-hook state with the power on, with the power on. Reverse the tip and ring connections and repeat the procedure.

Connect in turn, each of the TDD tip and ring conductors to a terminal of the variable dc power supply with the other terminal connected to metal foil which connects all exposed metal surfaces, ground, and all conductors other than the one being tested and the power leads. Determine the minimum voltage-versus-current ratio with power off and if the TDD can be in the on-hook state with the power on, with the power on. Repeat these measurements and calculations with the connections to the variable power supply reversed.

The lowest calculated ratio obtained is the required dc resistance.

4.2.2.2 AC Impedance

The requirements of this section are for a TDD without ring detection intended to be wired in parallel with a telephone used to originate and answer calls. TDDs with ring detection shall meet the alternating current characteristics and ringer sensitivity requirements of RS-470, Telephone Instruments with Loop Signaling for Voiceband Applications. TDDs without ring detection meeting the requirements of this section will work with all of the ringing types specified in EIA RS-470.

4.2.2.2.1 Tip to Ring During Ringing

The on-hook ac tip-to ring- impedance shall be greater than 10 kilohms (REN) over the frequency range of 15.3 to 68 Hz for ac voltages from 40 to 150 Vrms superimposed on up to 105 Vdc of either polarity. The total dc current flow as a result of the ac voltage shall not exceed 0.6 mA (REN), and it is desirable that it not exceed 0.2 mA (REN).

4.2.2.2.2 Tip to Ring During Quiescent State

The on-hook ac tip-to-ring impedance in the absence of ringing shall be in the acceptable region as shown in Figure 3 and Figure 4.

4.2.2.2.3 Tip and Ring to Ground During Ringing

The on-hook ac tip-to-ground and ring-to-ground impedances shall be greater than 100 kilohms over the frequency range of 15.3 to 68 Hz for ac voltages of 40 to 150 Vrms superimposed on up to 105 Vdc of either polarity.

4.2.2.2.4 Tip and Ring to Ground Quiescent State

The on-hook ac tip-to-ground and ring-to-ground impedances shall be greater than 20 kilohms over the frequency range 60 to 660 Hz for voltages up to 50 Vrms.

4.2.3 Off-Hook Impedances

4.2.3.1 DC Resistance

The upper limit for the dc resistance between tip and ring of a direct-connected TDD is determined by the ability of the device to draw adequate current for control of CO relays over a range of loop resistance and CO battery voltage. More current is required for the on-hook to off-hook transition than holding an off-hook connection (where the CO relays are required only to hold their energized state). The lower limit from tip-to-ground and ring-to-ground is necessary to limit unnecessary ground current flow.

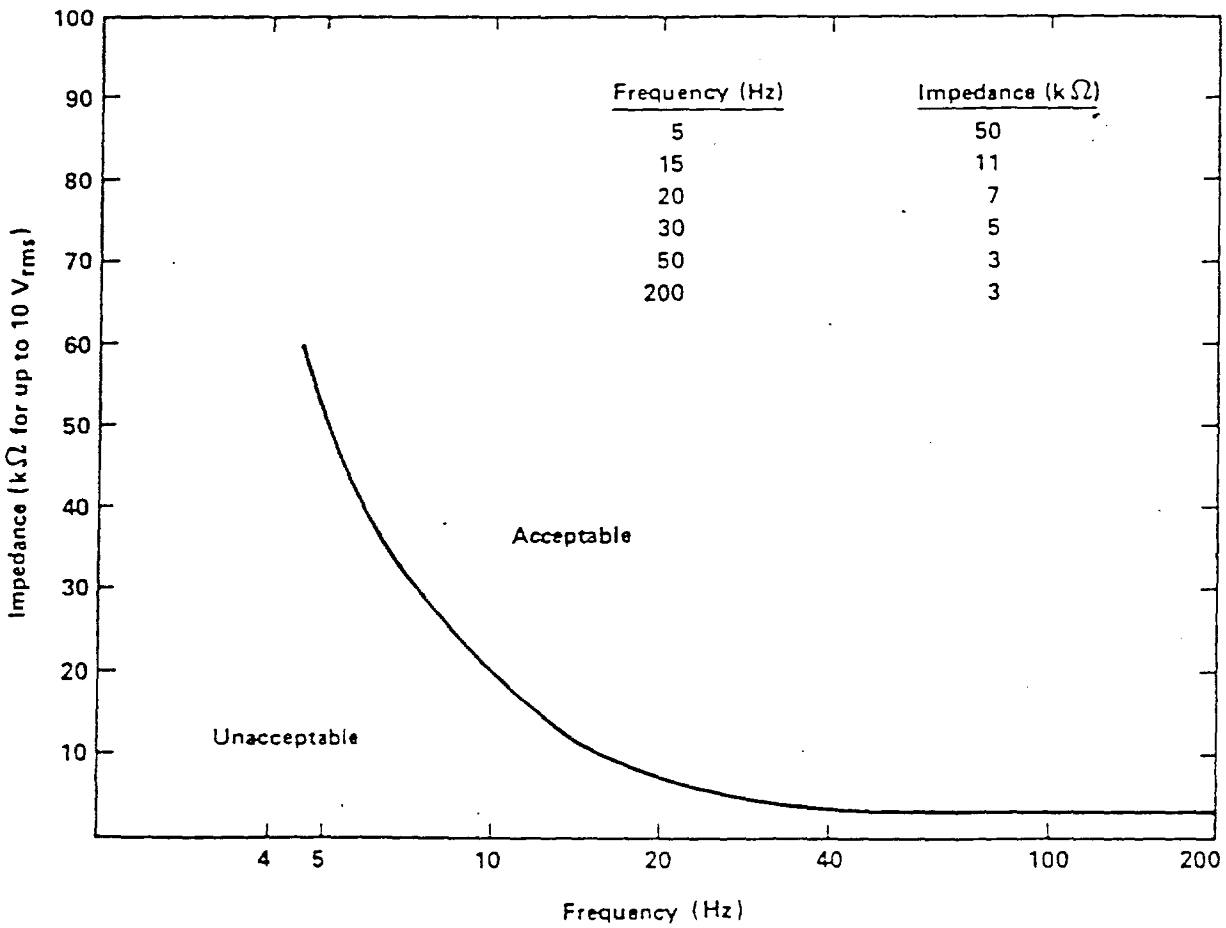


FIGURE 3 ON-HOOK TIP-TO-RING IMPEDANCE
5 TO 200 HZ DURING QUIESCENT STATE

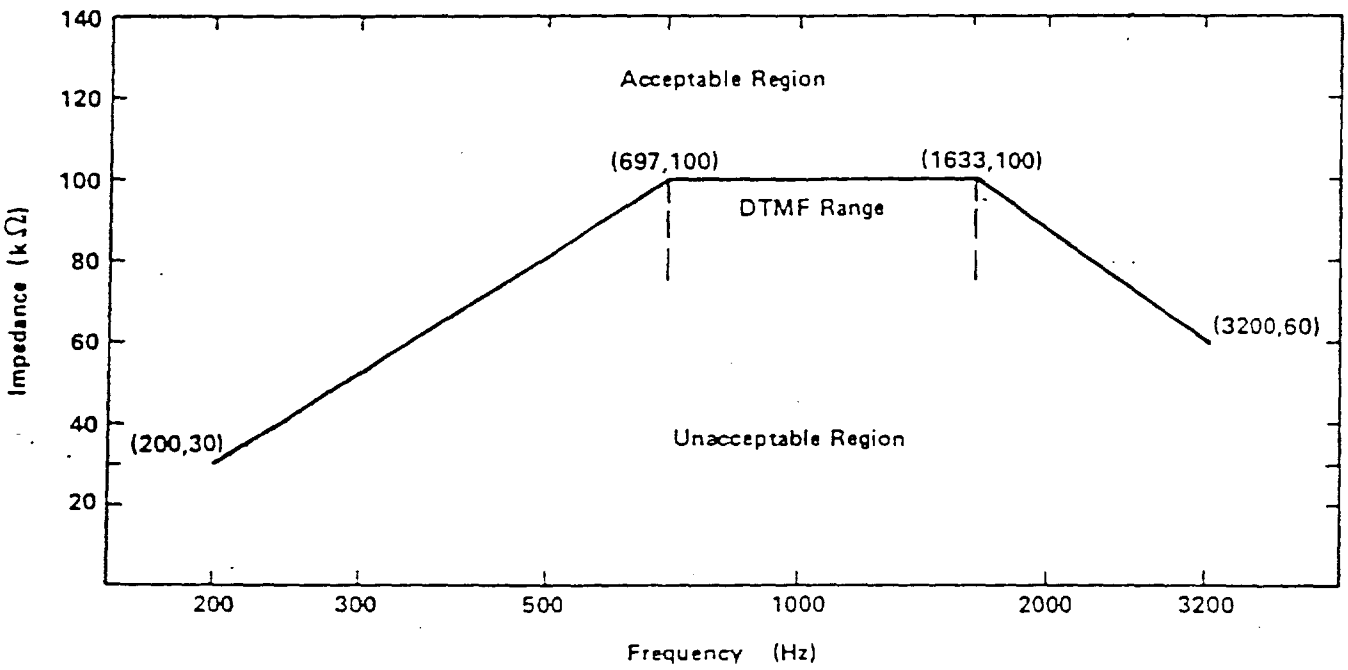


FIGURE 4 ON-HOOK TIP-TO-RING IMPEDANCE
200 TO 3200 HZ DURING QUIESCENT STATE